

Socioeconomic Status and the Brain: A Fuzzy-Trace Theory Approach to Address Concussion
Underreporting

Honors Thesis

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by

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Abstract

A growing body of evidence suggests that concussions in both adolescents and young adults are often overlooked, underreported, and inadequately treated. Failing to report symptoms associated with a concussion frequently leads to unfavorable health outcomes. The current two-part study aimed to evaluate theoretical predictions about reporting intentions in a heterogeneous sample that includes both athletes and non-athletes. Previous research applying fuzzy-trace theory (FTT) to health decision making suggests that gist-based thinking is protective against risky behaviors and intentions. Furthermore, the growing research highlighting why numeracy is such a stable predictor for effective decision making in various health contexts raises the question as to whether or not numeracy is likely associated with reporting intentions. In Study 1 ($n = 902$), we applied both FTT and objective numeracy to understand some of the decision-making processes that may promote concussion reporting. Consistent with FTT, analyses indicated that greater numeracy was significantly associated with higher reporting intentions at lower levels of gist processing. Main effects included gist processing and concussion knowledge. In Study 2 ($n = 466$), we turn our focus to socioeconomic status (SES) to investigate how SES, as indexed by free or reduced lunch status and parental education, may influence risk perception and the protective factors identified in Study 1. Bootstrapping indicated an indirect association between SES and reporting intentions via gist processing, risk perception, and concussion knowledge. Future interventions aimed at reducing concussion underreporting would likely benefit from considering how SES influences health outcomes.

Keywords: concussions, gist, fuzzy-trace theory, numeracy, risky decision making, socioeconomic status, risk perception

Concussion Underreporting

Traumatic brain injuries (TBIs) have grown in importance as a public health issue and is a serious health problem in the United States. The mounting evidence informs us that TBIs contribute to permanent disability and injury-related deaths. It is estimated that roughly 2.8 million Americans sustain a TBI each year (Taylor, Bell, Breiding, & Xu, 2017). Concussions, a form of a TBI, have been pointed to as the source of the increasing incidence of TBIs (Bloodgood et al., 2013). Unfortunately, concussions are often underreported which may mask the true numbers of those suffering from a concussion event. An untreated concussion has important implications for the developing brain, which may cause deficiencies in decision-making processes and behavior (Collins et al., 1999; Covassin & Elbin, 2010; Giza & Hovda, 2001; Guskiewicz, Ross, & Marshall, 2001; McCrea et al., 2003). Therefore, reporting concussion symptoms as they arise is crucial to reduce unintended consequences such as poor quality of life and death (Mez et al., 2017). In fact, a recent study done on athletes showed that those who immediately report their concussion symptoms not only recover faster but also return to play an average of five days sooner (Asken et al., 2016). Given the deleterious effects associated with an unreported concussion, it is necessary to elucidate the factors influencing reporting behaviors especially considering that many healthcare professionals heavily rely on self-reported signs and symptoms for a clear diagnosis.

In the context of sports, it is common for athletes not to report a concussion event to an authoritative figure. There are a variety of reasons for this, including not thinking the injury was serious enough and not wanting to disappoint teammates (Chrisman, Quitiquit, & Rivara, 2013; Delaney, Lamfookon, Bloom, Al-Kashmiri, & Correa, 2015; Kroshus, Garnett, Hawrilenko, Baugh, & Calzo, 2015; McCrea et al., 2004). Existing studies have rightfully made athletes the

primary focus when determining the barriers to concussion reporting; however, concussions also take place outside of sports (Haarbauer-Krupa et al., 2018). Non-sport causes of concussion (e.g., falls and motor vehicle accidents) not only explain a great amount of variability of concussion incidence but also can elicit as much (or more) damage to the brain as those sustained in collision and contact sports (Taylor et al., 2017). Perhaps the biggest difference between concussions sustained in sports versus non-sports are the opportunities to report a concussion event. In sports, coaches and athletic trainers are often readily available to allow athletes to report their injury and proceed with the necessary protocol of addressing the signs and symptoms. However, such opportunities to report could be less likely to occur at home or in the workplace. Thus, a concussion is most likely to elicit different responses depending on the context. The CDC has recently concluded that the majority of concussions are related to sports (70%); however, 30% are due to non-sports activities. The same study also determined that just 40% of all concussions are most likely attributed to contact and collision sports, whereas activities in non-sports accounts for the remaining 60% concussions (Haarbauer-Krupa et al., 2018). Currently, existing practices and policies are designed to safeguard athletes from the undesirable consequences of an underreported concussion. However, we do not know if these same practices and policies are able to benefit those with little to no athletic experience (non-athletes). Accordingly, there is a need to determine whether or not nonathletes and athletes differ in any protective behaviors that promote concussion reporting.

The prevalence of concussion underreporting is surprising considering its short and long term health effects (Bey & Ostick, 2009; Iverson, Gaetz, Lovell, & Collins, 2004; Khurana & Kaye, 2012). Fittingly, the growing literature has attempted to pinpoint underlying reasons for underreporting. One may reasonably suspect that increasing concussion knowledge may reduce

the likelihood that a person underreports because he/she is aware of the catastrophic consequences involved. However, the research supporting this claim is not convincing as concussion knowledge has been found to have no statistical effect on reporting intentions or behavior (Kroshus, Garnett, et al., 2015; Wallace, Kovan, Covassin, Nogle, & Gould, 2017). Relevant knowledge may be needed to determine specific symptoms associated with a concussion; however, it may not be sufficient to encourage reporting. While investigations of concussion knowledge are warranted, the existing evidence supports the need to incorporate psychological theories. Current studies have focused on the theories of planned behavior and reasoned action, that is, on the psychosocial aspects of behavioral intentions (Kroshus, Baugh, Daneshvar, & Viswanath, 2014; Kroshus, Garnett, et al., 2015; Register-Mihalik, Guskiewicz, et al., 2013; Register-Mihalik, Linnan, et al., 2013). However, using these theories as a conceptual framework tends to leave a fair amount of the variance unexplained in concussion reporting (Kroshus et al., 2014; Kroshus, Garnett, et al., 2015). To date, studies incorporating the cognitive aspects of decision-making and risk-taking to explain concussion reporting are limited. In the present study, we take an innovative approach by using fuzzy-trace theory (FTT) to capture the variance not accounted for in concussion reporting.

Introduction to Fuzzy-trace Theory

FTT is a dual-process theory of reasoning that posits that healthy decision making is based on more meaningful representations of information, the bottom-line message or “gist” processing than on precise, quantitative representations or “verbatim” processing (Reyna & Brainerd, 1995, 2011; Wilhelms & Reyna, 2013). The two forms of mental representation (gist and verbatim) are encoded and retrieved simultaneously, though separately (Reyna, 2012; Reyna & Kiernan, 1994). Gist processing relies on the extraction of qualitative understanding and

overall meaning, whereas verbatim processing focuses on the quantitative measurements and other surface-level details. These two opposing processes of FTT have been used to explain why people make tradeoffs between risk and reward (Reyna, 2018). The shift from verbatim to gist processing occurs with development. In making decisions that involve risk, adolescents tend to rely on verbatim processing, which not only facilitates the precise calculation of the risk but also trading risk for reward. In contrast, adults are likely to rely on gist processing to quickly make categorical distinctions of the risk while engaging their core values. Thus, trading risk for reward seems improbable. The described developmental shift does not necessarily mean that adolescents are superior quantitative thinkers compared to their older counterparts. Compared to adults, adolescents simply have an increased preference for analytical approaches when it comes to risk-taking. In addition, the endorsement of gist representations is not restricted to adults. Mills, Reyna, and Estrada (2008) found that adolescents who endorse gist representations engaged more in health-protective behaviors. Thus, risk can be thought of in many different ways based on where an individual falls on the FTT spectrum.

Additionally, the formation of gist traces is not only more developmentally advanced but also is affected by past experience, emotion, and other factors that may interfere with the meaning of a given situation (Reyna & Brainerd, 2011). The existing literature has supported the notion that an increased reliance on gist processing and not verbatim processing is protective against maladaptive behaviors (Mills, Reyna, & Estrada, 2008; Rivers, Reyna, & Mills, 2008; White, Gummerum, & Hanoch, 2015; Wilhelms & Reyna, 2013). Therefore, FTT suggests that verbatim processes might be more likely to reduce concussion reporting intentions and subsequent behavior, whereas gist processes might be more likely to have the opposite effect.

As per FTT, core values are represented by vague or fuzzy long-term memories, such as

“I have a responsibility to avoid getting a fatal disease.” Applied to concussion reporting, such a principle might be “I have a responsibility to myself not to take risk,” used in the present studies. Fuzzy guidelines are at the core of gist principles and are retrieved based on meaningful cues (Reyna, 2012). Accordingly, a categorical thinking of risk, which serves as a guideline for a gisty cue, supports the application of relevant bottom-line principles and values. The combined contributions of healthy bottom-line values endorsement, categorical thinking, and seeking relevant knowledge facilitate developmentally-advanced gist-based intuition that reduces unnecessary risk-taking (Mills et al., 2008; Reyna & Mills, 2014). FTT also predicts that with the accumulation of life experiences and age development, people are more inclined to base their decisions on simple gist representations and principles as opposed to more precise mental representations of values (Reyna et al., 2011; Reyna, Chick, Corbin, & Hsia, 2014; Reyna & Farley, 2006). Therefore, categorical representations of decision options and healthy gist principles fit together like a lock and key with respect to memory retrieval, which has been shown to safeguard against risky decision making. Finally, gist representations have also been shown to endure over time, to be easier to mentally manipulate and to be less subject to interference (e.g., from high arousal or emotion)—all of which should help decision-makers make informed decisions without impulsive urges (Reyna & Brainerd, 2011).

Numeracy and Decision Making

Numeracy is the ability to understand and manipulate numbers and it has become increasingly important for general decision-making skill. Furthermore, operating independent of fluid intelligence, numeracy tends to be a stable predictor for making both effective and rational decisions when it comes to health-related behaviors (Dieckmann et al., 2015; Peters et al., 2017). A likely reason for this is that scales designed to measure numerical ability may also assess

metacognitive processes involved in making rational choices (Halpern, 1998; Peters & Bjälkebring, 2014; Schoenfeld, 1992; Stanovich, 2012). The literature suggests that the ability to make effective decisions and the ability to efficiently manipulate numbers (e.g., calculation of probabilities) may both originate from the same set of metacognitive skills. To date, several theories have been used to explain the predictability of objective numeracy on health-related behaviors; candidates include gist processing, metacognition, and number-sense processes (Corbin, Reyna, Weldon, & Brainerd, 2016; Ghazal, Cokely, & Garcia-Retamero, 2014; Lipkus & Peters, 2009; Mueller & Brand, 2018; Patalano, Saltiel, Machlin, & Barth, 2015; Peters et al., 2006; Peters, 2012; Peters, Baker, Dieckmann, Leon, & Collins, 2010; Peters, Hibbard, Slovic, & Dieckmann, 2007; Reyna, 2004; Reyna & Brainerd, 2007; Reyna, Nelson, Han, & Dieckmann, 2009).

Despite the associated benefits of numeracy noted, more work needs to be done to further elucidate reasons as to why numeracy is such a reliable predictor of general decision making. Furthermore, the existing research contains little evidence on how the relationship between numeracy and performance on a health decision making task may operate in the presence of a third variable (moderator). What some theories in the literature have suggested is that highly numerate individuals are more precise in their mental representations of probabilities compared to the less numerate (Halberda & Feigenson, 2008; Lipkus & Peters, 2009; Peters, Slovic, Västfjäll, & Mertz, 2008). Accordingly, numeracy may not act entirely independent from gist processing (Reyna et al., 2009). Although verbatim and gist processes play a role in numeracy, gist reliance has been shown to continuously support healthier and more robust decisions (Brust-Renck, Royer, & Reyna, 2013; Reyna et al., 2009). Based on where one falls on the FTT spectrum, it is possible that numeracy may play a less influential role on both numeric and non-

numeric decisions involving risk. Corbin, Reyna, Weldon, and Brainerd (2016) subscribe to this idea by noting that more active monitoring and higher mathematical skills do not necessarily improve cognitive performance if the resulting analysis reflects verbatim processing—that is, engaging memorized skills such as conversion of percentages without deeper conceptual thinking (Corbin et al., 2016).

Why Socioeconomic Status Matters

Higher cognitive functions are supported by normal brain development, which is shaped by early experiences that includes nurturing environments (Bradley & Corwyn, 2002; Giedd et al., 1999; Hayward & Gorman, 2004; Markus & Stephens, 2017; Noble et al., 2015; Rosenzweig, 2003; Sowell et al., 2003). Since experiences are bound to vary as a function of SES, it is of no surprise that the theoretical construct is a robust predictor for an array of health outcomes, including physical and psychological health (Blackwell, Hayward, & Crimmins, 2001; Bradley & Corwyn, 2002; Preston & Taubman, 1994). The correlates of low SES, particularly as they relate to behavioral functioning and brain development, has important implications for our society. The characterization of SES frequently includes education, income, and occupation and all three of these measures promote a way of life and a pattern of values. Martin B. Loeb (1953) subscribes to this idea:

Because of the prolonged intimate relationships especially during childhood, each social class develops a pattern of behavior and a value system which differentiates it from the others. This is the theme that runs through the many ways in which one may look at social class in America. (p. 168)

This prompts the salient question: Does the SES gradient allow for different value orientations that may consequently affect certain psychological processes involved in effective decision-

making? Taken as a whole, the literature suggest that the conditions of SES shape preferences for healthy (and unhealthy) behaviors, which include physical activity, sexual activity, smoking, alcohol consumption, and diet (Aggarwal, Monsivais, & Drewnowski, 2012; Brodersen, Steptoe, Boniface, & Wardle, 2007; Businelle et al., 2010; Hiscock, Bauld, Amos, Fidler, & Munafò, 2011; Huckle, You, & Casswell, 2010; Langille, Hughes, Murphy, & Rigby, 2005; Lê et al., 2013; Upchurch, Aneshensel, Sucoff, & Levy-storms, 1999; van Oers, Bongers, Van De Goor, & Garretsen, 1999). Given the wide-ranging risky behaviors that SES stimulates, we have good reason to suspect that SES allows for differential socialization towards health promoting decision-making processes, which in turn may encourage different value orientations that guide behavior (Hayward & Gorman, 2004). Accordingly, we would agree with the aforementioned question. Available research has also suggested that the culture of high SES promotes certain values that may act as psychological buffers against poor health (Duncan, Magnuson, & Votruba-Drzal, 2017; Levine, 2017).

SES has been theorized to be a distal factor influencing brain development through mediating mechanisms, which then have a direct impact on behavior (Bronfenbrenner & Morris, 1998). The growing literature of SES informs us that there are indeed a host of neurocognitive outcomes, including executive function (EF), that are associated with SES (Jensen, Berens, & Nelson, 2017; Last, Lawson, Breiner, Steinberg, & Farah, 2018; Merz, Wiltshire, & Noble, 2018; Noble, McCandliss, & Farah, 2007). EF is of particular interest in this study because it serves as a foundational unit for decision making ability and goal-directed behavior which both have important implications for concussion reporting (Alloway & Alloway, 2010; Clancy Blair, 2013; Bull, Espy, & Wiebe, 2008; Daneman & Merikle, 1996; Shallice & Burgess, 1996; St Clair-Thompson & Gathercole, 2006; Ursache, Blair, & Raver, 2012). In fact, a large part of the

variance in gist reasoning, which we have adopted measures for in the present study, can be explained by performance on EF (Vas, Spence, & Chapman, 2015). Although some studies have shown gist reasoning to be independent of working memory, a component of EF, we nonetheless agree with the existing evidence that EF is central for healthy decision making (Corbin, McElroy, & Black, 2010; Reyna, 2012). The mounting evidence confirms that EF, which includes working memory, planning, and inhibitory control, is negatively impacted by the conditions of low SES. (Blair & Raver, 2012; Blair, 2010; Evans, 2004; Evans & Kim, 2013; Evans & Schamberg, 2009; Lawson & Farah, 2017). This is of importance when we consider that reading comprehension and mathematical ability, skills necessary for everyday tasks, are dependent on EF and vary as a function of SES (Alloway & Alloway, 2010; Bull et al., 2008; Crook & Evans, 2014; Daneman & Merikle, 1996; Demir-Lira, Prado, & Booth, 2016; St Clair-Thompson & Gathercole, 2006). Moreover, theories that attempt to explain variance in actual behavior and the underlying mechanism promoting health behavior change are grounded on the ability to plan effectively (Ajzen, 1991; Blume & Marlatt, 2009). Memory is another neurocognitive domain with well-attested effects of SES (Czernochowski, Fabiani, & Friedman, 2008; Farah et al., 2006; Herrmann & Guadagno, 1997; Noble et al., 2015; Noble, Houston, Kan, & Sowell, 2012; Noble et al., 2007). The described brain and behavioral links of SES may make it harder for some individuals to avoid the catastrophic consequences of not reporting especially when there are immediate benefits that are or could be available.

In the context of concussions, only one study has suggested SES differences in concussion knowledge and the decision to report a concussion injury (Wallace, Covassin, Nogle, Gould, & Kovan, 2017). However, we know that the meager research on SES as it relates to concussions reporting does not reflect its relevance. We suspect that concussion underreporting

may in large part be a consequence of SES at the psychological and neurological levels. Among low SES individuals, a psychological explanation for the decision to not report a concussion event may be driven by rational processes that make it hard to consider the effects of an untreated concussion when dire needs (e.g., food and shelter) need to be met. Wallace and colleagues have noted that a higher percentage of those in poverty areas chose not to report because of the financial burden associated with seeking medical care (Wallace, Covassin, et al., 2017). Consequently, hanging on the lower rungs of SES may have important implications for general risk-seeking behaviors.

Income, education, and occupation are powerful factors of health that are not likely to have a direct effect per se but may serve as proxies for other direct determinants (Angell, 1993). However, what appears to be a direct impact of SES on a health decision making task involving risk may also be operating through other variables that have more immediate effects. In the context of concussion reporting, we hypothesized that the maladaptive psychological processes associated with SES, particularly as they relate to the development of working memory and planning, are likely to encourage reduced concussion reporting intentions and associated behavior. Aside from the neurological processes associated with EF that are at stake, we theorize that the conditions associated with lower SES could condition an individual to endorse values that are maladaptive to decision making. For example, sustaining a serious injury such as a concussion may make it less appealing to report the symptoms and quickly recover given the possibility that time may be taken away from activities that generate income. When pressing needs that are satiated with income are confronted with the opportunity to fully regain health, we see low-SES individuals forgoing the latter for the former, which from an economic point of view is rational (Adler & Newman, 2002; Pampel, Krueger, & Denney, 2010). In the context of

sports, America has recently recognized the long-term health consequences of football (e.g., early death and CTE) and is moving away from the sport yet families in low-SES will decide that the benefits outweigh the risks (Samaha, 2018). We suggest that these families might view football and similar contact sports as a means of moving up the SES ladder, thereby making it less likely for athletes to report concussions (and not jeopardizing their chances to play in their respective sport). Economists have argued that the conditions of low-SES provide less reason to invest in future longevity and more reason to focus on the present in making health-related decisions (Cutler & Lleras-Muney, 2008; Griskevicius, Tybur, Delton, & Robertson, 2011). Despite knowing some of the deleterious effects associated with SES, the existing literature argues that the processes by which SES exerts its well-attested effects are not adequately understood (Bradley & Corwyn, 2002; Conger & Donnellan, 2007). All factors considered, there is a scientific interest to elucidate the indirect routes by which SES may influence concussion reporting.

The mediators used in the mediation analysis are not thought to be mutually exclusive. For example, higher impulsivity may lead to more lifetime concussions or vice-versa. Although concussion reporting intentions are of primary interest in the current study, we examine how proximal factors of reporting intentions (e.g., concussion knowledge and gist processing) are influenced by SES. Mediation analysis will allow us to better understand the processes involved with SES. This can inform effective interventions, especially when the constructs of SES— income, education, and occupation—cannot be easily adjusted. To our knowledge, there has been no study to date that details potential mechanisms in which SES effects health-related decisions at the behavioral level. By dissecting these mechanisms, we are better able to understand the multifarious ways SES effects behavior while effectively helping those low in

SES.

Present Study

Study 1 examined the relationship between numeracy and a non-numeric health decision making task (concussion reporting intentions) and investigated if the relationship varied based on healthy gist processing (see Figure 1). Therefore, the extent to which objective numeracy skills predicted a concussion-related protective behavior, after accounting for relevant knowledge, demographic characteristics, and other confounding factors will be investigated. No study to date has examined how healthy gist endorsement and numeracy relate to a health decision making task with implications of risk (e.g., concussion reporting). The assumption that this Study makes is that those who are highly numerate are more comfortable distorting probabilities. Therefore, numeracy can be associated with a focus on precise numbers and encourage reasoning to be too literal. The majority of the existing numeracy literature has failed to control for general cognitive ability, which makes it difficult to parse out the unique contributions of numeracy. The present study does not make this mistake as all subjects responded to the Raven's Progressive Matrices test of general fluid intelligence. Study 2 expands on the theoretical idea that SES impacts decision making and is a meaningful distal factor to explain some of the variability in reporting intentions. Using multiple predictors and comparing their effects, we illustrate how the mechanism of the SES effect is important. Thus, for the current study, we have attempted to characterize the critical pathogenic features associated with low SES and determine how they may affect concussion reporting intentions. It is important to note that race/ethnicity is not only related to SES in multifarious ways but also is not completely independent from each other in the United States (Herman, 1996; Kaufman & Cooper, 2001; Williams, 1997; Williams, Mohammed, Leavell, & Collins, 2010; Williams, Priest, & Anderson,

2016). Given the complex relations between these two constructs, we statistically controlled for race/ethnicity in the mediation analysis to determine unique contributions of SES. Age in years, sex, and athletic status were also included as covariates. Although we agree that the likelihood of sustaining a concussion event is high in sports, we do not ignore the fact that a concussion event is possible outside of a sports context. Thus, this present study incorporates both athletes and nonathletes to provide a clear picture of the barriers and facilitators of concussion reporting.

STUDY 1: POTENTIAL RELATIONSHIPS WITH CONCUSSION REPORTING INTENTIONS

Materials and Methods

Participants

Participants were 902 students (792 college undergraduates and 110 high schoolers) from various states across the United States. Participants took part in the study for either course credit, monetary compensation, or on a volunteer basis. The mean age of college undergraduates was 19.73 ($SD = 1.34$) and for high schoolers 16.74 ($SD = 1.45$). The majority in both age groups was female (69.2% and 51.8%, respectively) and considered an athlete (62.1% and 76.4%, respectively). Among college undergraduates, 50% identified as White (European descent), 15.2% as African American, 25.9% as Asian, and 8.8% as mixed/other; 10.5% identified as Hispanic. Among high schoolers, 51.8% identified as White (European descent), 21.8% as African American, 13.6% as Asian, and 11.8% as mixed/other; 21.8% identified as Hispanic. The Institutional Review Board of Cornell University approved the study. Participants under 18 years of age provided informed assent and parental consent whereas those over 18 years of age provided informed consent.

Measures

Categorical Thinking of Concussions: The Categorical Gist Thinking scale ($\alpha = .88$) assessed an individual's ability to think categorically about risk. FTT postulates that more categorical thinking (e.g., comparing "some" risk to "no risk") as opposed to weighing objective values of risks and benefits will be associated with healthier real-life outcomes (Lloyd & Reyna, 2009; Reyna et al., 2011). The scale in question consists of 25 items (e.g., "It is ok to risk injury from time to time") in which participants rated on a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" their agreement with each item. Higher scores indicate the ability to think categorically about concussions.

Gist Principles of Concussions: The Gist Principles of Concussions scale ($\alpha = .82$) consisted of 18 items (e.g., "I have a responsibility to myself not to take risks") and assessed bottom-line values that predict choices being made under risk and uncertainty. In essence, the scale captures the simple values that people retrieve and then apply to the representation of options in order to make decisions. The 5-point Likert scale was again used to input ratings for each item. Higher scores indicate the ability to access a value system and draw on less precise mental representations of a concussion.

Objective Numeracy Scale (ONS): The 15-item Objective Numeracy Scale (ONS) ($\alpha = .87$) was included in order to assess quantitative judgments concerning fractions, chance, proportions, and percentages. An example of an item from this scale is as follows: "If Person A's risk of getting a disease is 1% in 10 years, and person B's risk is double that of A's, what is B's risk?" (Peters et al., 2007). Each item on the scale required participants to input a numerical response. Correct responses were assigned a value of one point and were then averaged for data analysis with a range from zero to one. Higher scores were indicative of higher numeracy, a skill

that requires quantitative processing.

General Intelligence: As a measure of reasoning ability, the validated 12-item Ravens Advanced Progressive Matrices Test was used ($\alpha = .84$) (Arthur & Day, 1994). All of the questions consist of a geometric design that contains a missing piece. Participants choose from eight pictures to complete the pattern. Each correct chosen pattern was assigned a value of one point. A sum of correct responses was used to create a general intelligence score with a range from 0 to 12. A higher composite score on the Ravens Advanced Progressive Matrices Test is indicative of higher general fluid intelligence. The Ravens Advanced Progressive Matrices Test enables for the independent assessment of objective numeracy.

Concussion Reporting Behavioral Intention: Symptom reporting intention was assessed by querying the 22 symptoms listed in the Sport Concussion Assessment Tool-5th edition ($\alpha = .98$) (Kroshus, Garnett, et al., 2015; McCrory et al., 2017). An example of an item from this scale is as follows: “In the future, I intend to report my symptoms if I sustain an impact that causes me to feel pressure in my head.” Response options were provided on the 7-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.” The mean of each response was taken to obtain a unique score for each participant. Higher scores reflect higher intentions to report symptoms associated with a traumatic brain injury.

Concussion Knowledge: The Rosenbaum and Arnett’s (2010) Concussion Knowledge Index was used to assess participant’s concussion knowledge ($M = 18.67$, $SD = 2.27$). The validated 25-item scale contained three sections. The first section contained 15-items and assessed knowledge of the causes and consequences of a concussion (e.g., “There is a possibility of death if a second concussion occurs before the first one has healed”). The second section included three applied items that were used to again assess knowledge of the causes and

consequences of a concussion (e.g., “While playing in a game, Player Q and Player X collide with each other and each suffers a concussion. Player Q has never had a concussion in the past. Player X has had 4 concussions in the past”). The last section included a checklist in which participants needed to check off if they believed it was likely to occur after suffering a concussion (e.g., “Think about someone who has had a concussion. Check off the following signs and symptoms that you believe someone may be likely to experience AFTER a concussion”). Items that were incorrectly answered received 0 points and items that were correctly answered received 1 point. Scores for each item were added for the Concussion Knowledge Index with scores ranging from 0-25 and with higher scores indicative of higher levels of concussion knowledge.

Impulsiveness: The Barret Impulsiveness Scale ($\alpha = .83$) (BIS-11; (Stanford & Barratt, 1995) is the most widely cited instrument for the assessment of impulsiveness and was administered to assess impulsive behaviors and preferences. An example of an item from this scale is as follows: “I am more interested in the present than the future.” Each of the 30 items was rated on a 5-point Likert scale. Some items are reverse scored and thus allowed participants to convey a more permissive attitude toward impulsive behaviors. Scores were then averaged for an impulsiveness score with higher values indicating higher impulsivity.

Concussion History: Self-reported history of diagnosed concussions was assessed with the item: “How many times in your lifetime have you been diagnosed with a concussion in your entire life?” Responses were then coded as either zero, one, two, or three or more concussions ever diagnosed. Currently, there is controversy about the reliability of self-reported concussion history in behavioral research (Wojtowicz et al., 2016). Analyzing the consistency of self-reported concussion history, Wojtowicz and colleagues found males to provide inconsistent

concussion histories compared to females (Wojtowicz et al., 2016). To address concerns of self-reported concussions, demographic variables were statistically controlled for in relevant analyses.

Athletic Status: Self-reported athletic status was assessed with the item: “Are you a student-athlete?” Participants recorded their responses with the following options: “Yes,” “No,” and “I am not a student-athlete currently, but I used to be one.” Those who identified themselves as currently or formerly a student-athlete were classified as an “athlete” and those otherwise were classified as a “nonathlete.” Thus, a dichotomous variable was created to categorize those with and without athletic experience.

Analysis

To confirm that the two gist measures grouped together in theoretically predicted ways, we inputted the measures into a principal component analysis with orthogonal rotation (varimax). To examine the extent to which demographic information, independent and dependent variables shared variance, a correlogram with hierarchical clustering was utilized to display the bivariate correlational results (see Figure 2). A hierarchical linear model was then performed to evaluate the hypothesis that gist-based thinking would moderate the influence of ONS on reporting intentions after statistically adjusting for relevant covariates; however, without any consideration to statistical numeracy, higher gist processing of concussion will be sufficient to promote concussion reporting. To avoid multicollinearity, the terms used to construct the product interaction (ONS and GIST) were mean centered prior to analyses (Aiken & West, 1991). In step 1, self-reported measures of age, sex, concussion history, and athletic status were entered in addition to individual performances on the Concussion Knowledge Index, Barratt Impulsiveness, and Raven’s APM. For the purposes of this study, step 1 was considered the

“control” model. ONS and GIST were then entered subsequently in steps 2 and 3. Step 4 additionally included the ONS x GIST interaction term. The significant interaction term was then probed using simple slope analysis and J-N technique (Preacher, Curran, & Bauer, 2006). For the simple slope analysis, the conditional slope of ONS on concussion reporting intentions was examined at low (-1SD), average (mean), and high (+1SD) levels of GIST. When calculating the J-N interval(s) to identify a threshold of significance across all levels of the moderator values a false discovery rate adjustment was used to manage the Type I and II error rates (Esarey & Sumner, 2018). Therefore, we will be able to determine what range of the Gist factor the effect of ONS is significantly positive, nonsignificant, or significantly negative. All statistical analyses were conducted with SPSS 23 (IBM, Armonk, NY, 2015) and R 3.5.1 (R Core Team, Vienna, Austria, 2018).

Results

Relationships between Gist Measures: Principal Component Analysis

As per FTT, Categorical Thinking of Concussions and Gist Principles of Concussion scales loaded onto a single component with an eigenvalue of 1.71, which accounted for 85.36% of the variance (see Table 1). Note that these variables were not retroactively combined in any way; rather, the theoretically predicted grouping (GIST) emerged from the principal component analysis. Higher scores on GIST indicate the ability to draw on less precise mental representations and to apply simple gist values that encourage healthy decision making. The Cronbach’s alpha for all items used to create the two gist measures was high ($\alpha = 0.91$) suggesting that the Gist factor has a high reliability.

Hierarchical Linear Regression Analysis Predicting Concussion Reporting Intentions

Step 1 of the hierarchical model showed that concussion knowledge and general intelligence positively predicted intentions to report a concussion symptom, whereas concussion history and impulsivity served as significant negative predictors (change $F_{7,894} = 25.44, p < .001$). In layman terms, higher concussion knowledge and intelligence were predicted to increase concussion reporting intentions. Age, sex, and athletic status were insignificant predictors for the criterion variable in question. ONS was entered at step 2 and was a positive predictor of the outcome variable, in which higher levels of numerical ability led to higher reporting intentions. The added term accounted for a significant increase in variance (change $F_{1,893} = 19.24, p < .001$) while causing general intelligence to lose its predictive power and age to emerge as a negative predictor of intentions. Accordingly, older individuals were more likely to have lower reporting intentions compared to younger individuals. The results of the third regression model showed that the Gist factor additionally predicted reporting intentions (change $F_{1,892} = 260.37, p < .001$) such that higher levels of gist-based thinking led to an increase in reporting intentions. Despite the diminished predictive value for ONS, it still maintained its significance. Performance on the Barratt Impulsiveness scale was no longer predictive of intentions. The results of the final regression model (containing all predictors and covariates) showed that the interaction between ONS and GIST predicted concussion reporting intentions and added a statistically increased variance in the dependent variable (change $F_{1,891} = 17.03, p < .001$). The value of the interaction ($B = -.57, p < .001$) tells us the expected change in the linear form of ONS for a one-unit change in the Gist factor (and vice versa). Model estimates for ONS reduced appreciably from Model 3 and did not retain its statistical significance. Additionally, the largest standardized beta weight (accounting for the most variance) belonged to the Gist factor. The positive weight of the factor indicates that higher gist-based reasoning of concussions was

associated with higher intentions to report a concussion event. The R^2_{adjusted} for each step of the model, as well as the unstandardized regression coefficients (B), standard error (SE), and standardized regression coefficients (β), are reported for the current analysis (see Table 2).

Probing the Significant Interaction

There was a significant interaction effect between ONS and GIST when regressed on concussion reporting intentions ($b = -0.57, p < .001$). It bears mentioning that ONS loses its average effect in the final regression model, whereas statistical significance was maintained with the average effect of GIST. The simple slopes analysis (see Table 3 and Figure 3) revealed a significant positive relationship between ONS and intentions at -1 SD of GIST, $b = 0.70 (0.19), t = 3.77, p < .001$. The relationship between ONS and intentions at +1 SD of GIST was non-significant, $b = -0.44 (0.26), t = -1.70, p = .09$. There was no significant relationship between the two variables of interest at the mean, $b = 0.13 (0.18), t = 0.74, p = .46$. The conditional intercepts were significant at the three levels chosen for the Gist factor: ± 1 SD and mean. Subsequently, the J-N technique was used to determine regions of significance. When GIST was outside the interval $[-0.39, 1.31]$, the slope of ONS was $p < .05$ at the false discovery rate adjusted t value of 2.10 (see Figure 4). The observed range of GIST was $[-3.16, 2.80]$. This means that the conditional effect of objective numeracy on reporting intentions was statistically significant at low and high values of the Gist factor. As indicated by the negative slope of the J-N technique, positive and negative contributions of ONS on the outcome variable corresponded to lower and higher gist-based thinking of concussions (an inverse association).

Discussion

The results of the first study suggested that the broad predictive power of numeracy on decision-making tasks is limited by the consideration of gist processing (interaction). In the

absence of GIST, the average effect of numeracy was statistically sufficient to predict concussion reporting intentions. However, the simple slope analysis and J-N technique showed that the positive contributions of numerical ability were only applicable at lower levels of gist-based thinking. These results supported FTT's predictions that greater gist processing would be associated with higher concussion reporting intentions. Additionally, the average effect of gist-based thinking maintained statistical significance while the average effect of objective numeracy lost its predictability when both variables were simultaneously regressed on the dependent variable. This provided a clue that gist processes, as opposed to verbatim processes, are needed to promote concussion reporting intentions and the subsequent behavior to report a concussion event. Notice that the conditional intercepts for each slope at the mean, +1SD and -1SD of GIST were all significant. This indicates that without any consideration to objective numeracy, being on the higher end of the Gist factor was associated with higher reporting intentions. In the upcoming study, we investigate whether or not the positive factors identified in Study 1 may change due to SES.

STUDY 2: THE PSYCHOLOGICAL AND BEHAVIORAL CONSEQUENCES OF SOCIOECONOMIC STATUS ON CONCUSSION REPORTING INTENTIONS

Participants

Due to the late addition of a risk perception scale, a subsample of 466 participants (425 college undergraduates and 41 high schoolers) was drawn from the first study examining the potential influences on concussion reporting intentions ($n = 902$) (see above for details of recruitment criteria and procedure). Participants took part in the study for either course credit, monetary compensation, or on a volunteer basis. The mean age of college undergraduates was 19.50 ($SD = 1.22$) and for high schoolers 16.61 ($SD = 1.63$). The majority in both age groups

were female (72.5% and 63.4%, respectively) and considered an athlete (61.2% and 70.7%, respectively). Among college undergraduates, 48.2% identified as White (European descent), 15.8% as African American, 27.1% as Asian, and 8.7% as mixed/other; 12.2% identified as Hispanic. Among high schoolers, 22.0% identified as White (European descent), 43.9% as African American, 17.1% as Asian, and 17.1% as mixed/other; 14.6% identified as Hispanic. Although we agree that race and ethnicity serve two distinct purposes, both demographic variables capture ethnic or cultural variation causing many individuals to consider the terms as synonymous (Kaufman & Cooper, 2001; McKenney & Bennett, 1994; Williams, 1996). For parsimonious reasons, the two constructs were collapsed such that 58.6% of the college undergraduates and 78.0% of the high schoolers identified as Hispanic and/or non-White. The protocol for study approval, informed consent, and child assent were the same as in Study 1.

Measures

In addition to the measures identified in Study 1, participants responded to a risk perception scale. Provided with sports with varying degrees of contact level, participants responded to the following “Which of the following, do you feel, best represents the chances of receiving a concussion in the following sports?”. Responses were recorded using a rating scale from “none” to “high” and then placed into bins based on the contact level of the sport (i.e., collision, contact, non-contact). The average risk perception score for *collision* sports (5 items; $\alpha = .69$) was used as a proxy for one’s perception of high-risk situations that cues the possibility of a concussion event. Accordingly, higher scores reflect higher risk perception. It bears mentioning that both athletes and nonathletes were provided the same scale. Due to differing levels of experience, athletes may be more familiar with the risks involved with sports compared to nonathletes. However, because of the growing media attention sport injury risk has received

in recent years, we believe that nonathletes are still able to discriminate between the relative risks associated with different sports (Kennard, McLellan, & McKinlay, 2018; Kuhn, Yengo-Kahn, Kerr, & Zuckerman, 2017; Mannix, Meehan, & Pascual-Leone, 2016). To verify this notion, an independent samples *t*-test was performed to examine if there were any differences in the risk perception of collision sports between athletic groups. Results showed no statistical difference between athletes ($M = 3.54$, $SD = 0.45$) and nonathletes ($M = 3.48$, $SD = 0.45$); $t(464) = -1.36$, $p = .17$.

Socioeconomic Status

In the current study, we include two indicators of SES: free lunch status and parental education. Participants reported if they have ever received free/subsidized lunch. The Child Nutrition Programs run by the federal government offers reduced or free meals in school throughout the United States if a household falls below an income threshold. Additionally, as the federal income poverty guidelines are adjusted based on household size, eligibility for free or reduced lunch is also adjusted for household size. Therefore, participation in the National School Lunch Program can be a useful indicator for the household income-to-needs ratio. In addition to free/subsidized lunch status, participants also reported on the educational attainment of their parent(s). Parental educational attainment was reported in four categories: 1 = less than high school, 2 = completed high school or equivalent, 3 = some college after high school, and 4 = 4-year degree or more. When parental education information was provided for two caregivers, parental education was computed as an average of both caregivers. Higher scores on both SES measures were indicative of higher SES. Consistent with prior research, a composite indicator of personal SES was created by averaging the standardized (*z*-score) values of the two index variables— free/subsidized lunch status and parental education —for each individual (Gianaros

et al., 2007; Last et al., 2018; Swartz, Hariri, & Williamson, 2017). Participants who did not provide their free/subsidized lunch status and/or educational attainment for at least one parent were excluded from all analyses. In addition to the sample demographics, the retrospective non-normalized SES characteristics and the composite index formed are reported (see Table 4).

Analysis

Because there were no qualitative differences in the factor loadings of the two gist measures between the full and subset samples, the same Gist factor created in Study 1 was used for the assessment of gist processing in Study 2. All measures were correlated with each other to determine significant associations (see Figure 5). The SPSS macro program developed by Preacher and Hayes (2008) was then used to test the significance of the indirect effects and contrasting the strengths of indirect effects through six mediators. Mediators were tested simultaneously by calculating bias-corrected 95% confidence intervals (Cis) using bootstrapping with 10,000 resamples. Mediation analysis included age in years, sex, race/ethnicity, and athletic status as covariates. Regression/path coefficients are all unstandardized as standardized coefficients have no useful practical interpretation (Hayes, 2013).

Results

As predicted, the standardized parental education and free/reduced lunch variables were found to correlate significantly with each other ($r = 0.49, p < .001$). There were no sex differences and age association with the aggregate SES measure. However, there was a significant difference in the SES scores for those identified as Hispanic and/or non-white ($M = -0.24, SD = 0.97$) and those identified as non-Hispanic white ($M = 0.37, SD = 0.46$); $t(427.83) = 9.11, p < .001$.

Regression coefficient estimates – based on the use of 95% bias-corrected CI – were used as evidence for the indirect effects through six mediators: healthy gist endorsement, ONS, risk perception, impulsivity, concussion knowledge, and concussion history (see Figure 6). As shown in Table 5, the endorsement of healthy gist values, risk perception, and concussion knowledge fully mediated the relationship between SES and reporting intentions because the bootstrap CI was above zero while controlling for demographic variables. The total effect of SES on reporting intentions just missed significance ($c = 0.13$, $CI = 0.00-0.25$, $t = 1.95$, $p = 0.05$). Furthermore, when controlling for mediators' effect in the mediation analysis, the relationship between the independent and dependent variable remained insignificant. Thus, the results of the mediation analysis confirmed that gist, risk perception, and concussion knowledge had a full mediating effect. The total amount of variance accounted for by the overall model, which included SES, six proposed mediators, and the statistically controlled demographic variables was 35.73%.

General Discussion

Study 1 examined the extent ONS influences reporting intentions (non-numeric task) and then determined whether or not this relationship was moderated by the endorsement of healthy gist values. Measures used to evaluate gist thinking (Categorical Thinking and Gist Principles of Concussions) were designed to draw on less precise mental representations and to assess an individual's value system that might guide their choices. Accordingly, the objective of Study 1 was to evaluate psychological processes that might be at play as one decides to report symptoms associated with a concussion event. For Study 2, we turn our focus to SES to better understand the psychological and behavioral consequence of SES. In doing so, mediators were tested

simultaneously to determine potential mechanisms in which SES may operate to influence reporting intentions.

Both ONS and GIST were positively correlated with concussion reporting intentions. As per FTT, the predictability of ONS was moderated by GIST such that the positive association between numeracy and reporting intentions was predicted at lower levels of gist processing. Although numerical information is rarely provided when one reports symptoms associated with a concussion event it is likely that lower levels of gist endorsement facilitates in higher numeracy acting as a positive contributor to reporting intentions. As FTT predicts, a preference for verbatim processing encourages the reliance on precise representations of an unfavorable health outcome (risk). Therefore, one may reasonably suspect that the positive contribution of ONS on reporting intentions contradicts FTT. Upon further analyses, results are suggestive of numeracy acting in accordance with gist processing such that positive contributions of numeracy are only seen at lower levels of gist endorsement. The existing literature suggests that more objectively numerate individuals are likely to engage in health-protective behaviors than their less numerate counterparts. While we do not dispute the evidence, we believe that this effect is reliant on where one falls on the GIST spectrum. More studies are warranted to disambiguate between specific numerical processes measured in ONS that are maladaptive to decision making. The hierarchical regression results show that despite the associated benefits of numeracy, it pales in comparison to the potential gains that gist processing provides to promote increased reporting intentions. Nonetheless, our results complement the existing literature that supports the function of higher numeracy on health behaviors and outcomes. Besides GIST, concussion knowledge was sufficient to predict reporting intentions. Results also suggested that the variability in reporting intentions is best captured by gist processing of concussions.

GIST, risk perception, and concussion knowledge emerged as significant mediators between SES and reporting intentions when race/ethnicity, age, sex, and athletic status were statistically controlled for (Study 2). Results suggested that these mediators are most malleable to SES, which then in turn capture most of the variability in reporting intentions. As seen in Study 1, GIST was determined to be sufficient to promote concussion reporting. What the results from the compressive study suggest is that those in low SES may have difficulty encoding and retrieving gist traces used to form health gist values which will then have an impact on reporting intentions. According to the mediation analyses, GIST had the largest indirect size effect followed by risk perception and concussion knowledge. Interestingly, a direct effect between SES and reporting intentions did not exist. A likely reason for this is due to the limited variability in SES to encapsulate those at the lower end of SES.

Overall, the findings from the two-part study showed that gist processing, which entails categorical thinking and endorsement of healthy gist values, promotes increased reporting intentions. Also, mediation results suggest that those on the higher end of SES are on a pathway that promotes risk avoidance as it relates to concussion reporting. We advocate for the need for more research to determine if improvements in gist processing, risk perception, and concussion knowledge are worthwhile to reduce concussion underreporting in low-SES populations.

Limitations and Future Directions

One limitation of the present work is the relatively limited range of SES. Compared to the full range of socio-economic conditions in the United States, participants classified as low SES were relatively affluent. This may have reduced our power to detect significant effects that we may have otherwise seen (e.g., regression of SES on reporting intentions). Furthermore, individuals who are more resource-deprived and lack educated caregivers might have performed

worse relative to the sampled low SES population on measures used in this study. The mediating Gist factor, risk perception, and concussion knowledge may have been more profound in explaining the association between SES and concussion reporting intentions. Another limitation of the present work is that reporting behavior intentions rather than the actual behavior to report was used. However, the available research suggest that intentions are predictive of behavior (Kroshus, Baugh, Daneshvar, Nowinski, & Cantu, 2015; Sheeran, 2002).

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Table 1.

Principal Component Analysis for Gist Measures (n = 902)

| VARIABLE | FACTOR LOADING |
|------------------|----------------|
| Categorical Risk | .92 |
| Gist Principles | .92 |

Table 2.

Results of Hierarchical Regression Analysis Predicting Concussion Reporting Intentions

| REGRESSION STEP | R ² | F | B | SE | β |
|--|----------------|-----------|-------|------|---------|
| STEP 1 | 0.17 | 25.44*** | | | |
| Age | | | -0.03 | 0.02 | -0.05 |
| Sex (0 = male, 1 = female) | | | 0.08 | 0.07 | 0.03 |
| Concussion Knowledge | | | 0.15 | 0.02 | .29*** |
| Concussion History | | | -0.1 | 0.05 | -.07* |
| Athletic Status (0 = nonathlete, 1 = athlete) | | | -0.1 | 0.07 | -0.04 |
| Barratt Impulsiveness | | | -0.46 | 0.09 | -.17*** |
| Raven's APM | | | 0.03 | 0.01 | .08* |
| STEP 2 | 0.18 | 19.24*** | | | |
| Age | | | -0.04 | 0.02 | -.06* |
| Sex (0 = male, 1 = female) | | | 0.1 | 0.07 | 0.04 |
| Concussion Knowledge | | | 0.12 | 0.02 | .24*** |
| Concussion History | | | -0.09 | 0.05 | -.07* |
| Athletic Status (0 = nonathlete, 1 = athlete) | | | -0.09 | 0.07 | -0.04 |
| Barratt Impulsiveness | | | -0.4 | 0.09 | -.15*** |
| Raven's APM | | | 0.01 | 0.01 | 0.01 |
| ONS | | | 0.83 | 0.19 | .17*** |
| STEP 3 | 0.37 | 260.37*** | | | |
| Age | | | -0.04 | 0.02 | -.06** |
| Sex (0 = male, 1 = female) | | | 0.01 | 0.06 | 0 |
| Concussion Knowledge | | | 0.08 | 0.02 | .17*** |

| | | | | | |
|--|------|----------|-------|------|---------|
| Concussion History | | | -0.06 | 0.04 | -0.04 |
| Athletic Status (0 = nonathlete, 1 = athlete) | | | 0.11 | 0.06 | 0.05 |
| Barratt Impulsiveness | | | -0.08 | 0.08 | -0.03 |
| Raven's APM | | | 0 | 0.01 | 0 |
| ONS | | | 0.37 | 0.17 | .08* |
| Gist factor | | | 0.55 | 0.03 | .49*** |
| STEP 4 | 0.38 | 17.03*** | | | |
| Age | | | -0.05 | 0.02 | -.08** |
| Sex (0 = male, 1 = female) | | | 0.01 | 0.06 | 0 |
| Concussion Knowledge | | | 0.07 | 0.02 | .14*** |
| Concussion History | | | -0.05 | 0.04 | -0.03 |
| Athletic Status (0 = nonathlete, 1 = athlete) | | | 0.1 | 0.06 | 0.04 |
| Barratt Impulsiveness | | | -0.09 | 0.08 | -0.03 |
| Raven's APM | | | 0 | 0.01 | 0.01 |
| ONS | | | 0.13 | 0.18 | 0.03 |
| Gist factor | | | 0.56 | 0.03 | .49*** |
| ONS x Gist factor | | | -0.57 | 0.14 | -.13*** |

Note: ONS and Gist factor were centered at their means.

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 3.

Results of Simple Slope Analysis

| GIST FACTOR | SLOPE OF ONS | CONDITIONAL INTERCEPT |
|-------------|-----------------|--------------------------|
| -1 SD | 0.70 (0.19)*** | 4.94 (0.52)*** |
| mean | 0.13 (0.18) | 5.50 (0.51)*** |
| +1 SD | -0.44 (0.26) | 6.06 (0.51)*** |

*** $p < .001$.

Table 4.

Sample demographics (n = 466 subjects).

| VARIABLE | N (%) | MEAN (SD) |
|---------------------------|--------------|------------------|
| Gender | | |
| Female | 334 (71.7) | |
| Male | 132 (28.3) | |
| Age | | 19.24 (1.50) |
| Race/Ethnicity | | |
| Hispanic and/or non-White | 281 (60.3) | |
| Non-Hispanic White | 185 (39.7) | |
| SES | | |
| Free Lunch | 112 (24.0) | |
| Parental Education | | 3.58 (0.77) |
| Composite Index | | 0.00 (0.86) |
| Athletic Status | | |
| Non-Athlete | 177 (38.0) | |
| Athlete | 289 (62.0) | |

Table 5.

Indirect Effects of SES on Concussion Reporting Intentions Through Gist factor, ONS, Risk Perception, Barratt Impulsiveness, Concussion Knowledge, and Concussion History

| MEDIATOR | EFFECT | SE | 95% CI | |
|-----------------------|---------------|-----------|---------------|--------------|
| | | | LOWER | UPPER |
| Gist Factor | .07* | .03 | .03 | .13 |
| ONS | .00 | .01 | -.02 | .03 |
| Risk Perception | .05* | .02 | .01 | .10 |
| Barratt Impulsiveness | .00 | .01 | -.01 | .01 |
| Concussion Knowledge | .05* | .02 | .02 | .09 |
| Concussion History | -.01 | .01 | -.03 | .00 |

* p < .05; SE and 95% CI were estimated using bootstrapping with n = 10,000 samples

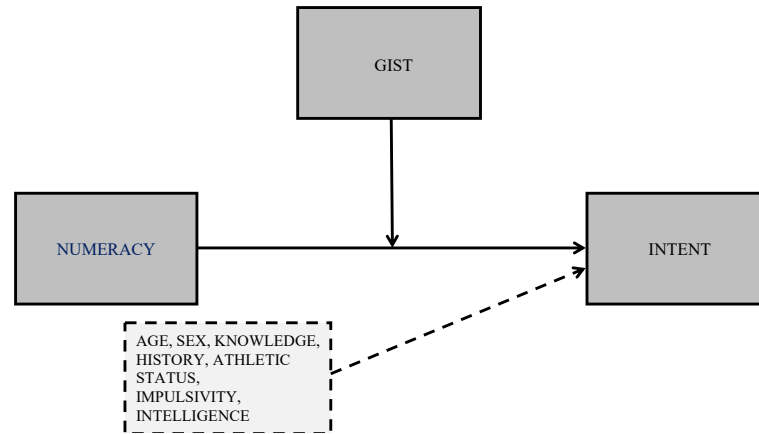


Figure 1. A hypothesized conceptual model displaying how the endorsement of healthy gist values moderates the predictive power of objective numeracy on concussion reporting intentions

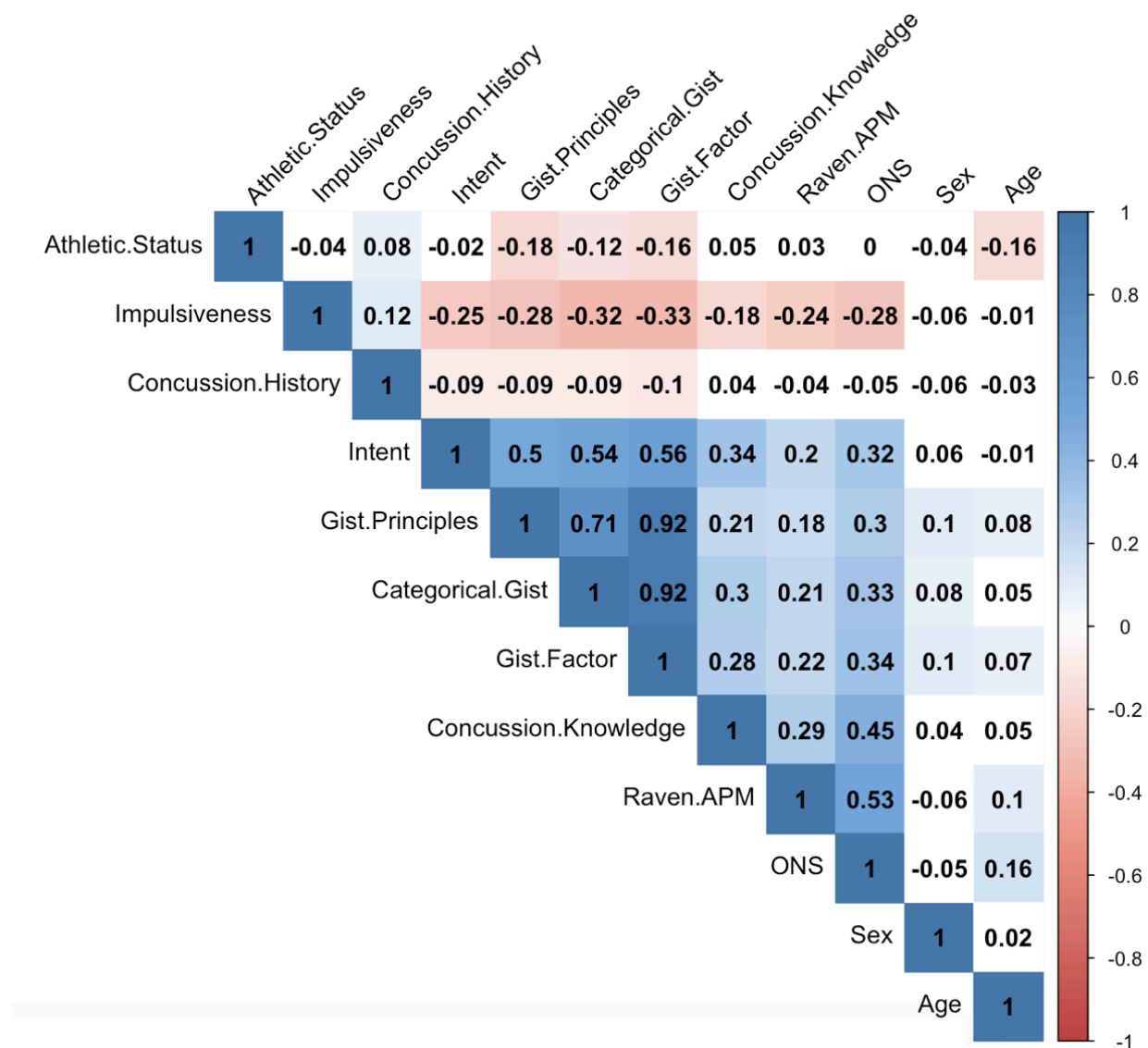


Figure 2. Correlogram of all measures used in Study 1. Pearson's Bivariate Correlation

Coefficients significant at the 0.05 alpha level are denoted by color. Hierarchical clustering was used to identify hidden structure and pattern in the matrix. Athletic status was coded as 0 for nonathlete and 1 for athlete. Sex was coded as 0 for male and 1 for female. Age was in years.

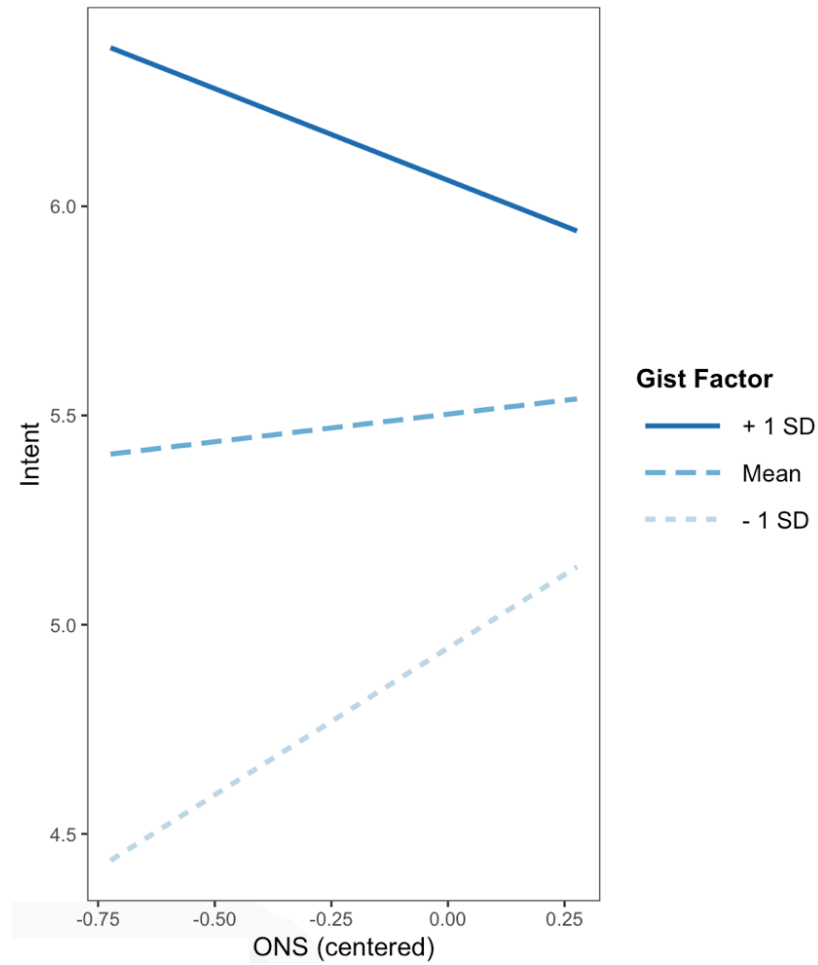


Figure 3. Simple slope analysis to investigate the relationship between numeracy and concussion reporting intentions at three levels of the Gist factor (-1SD, mean, and +1SD).

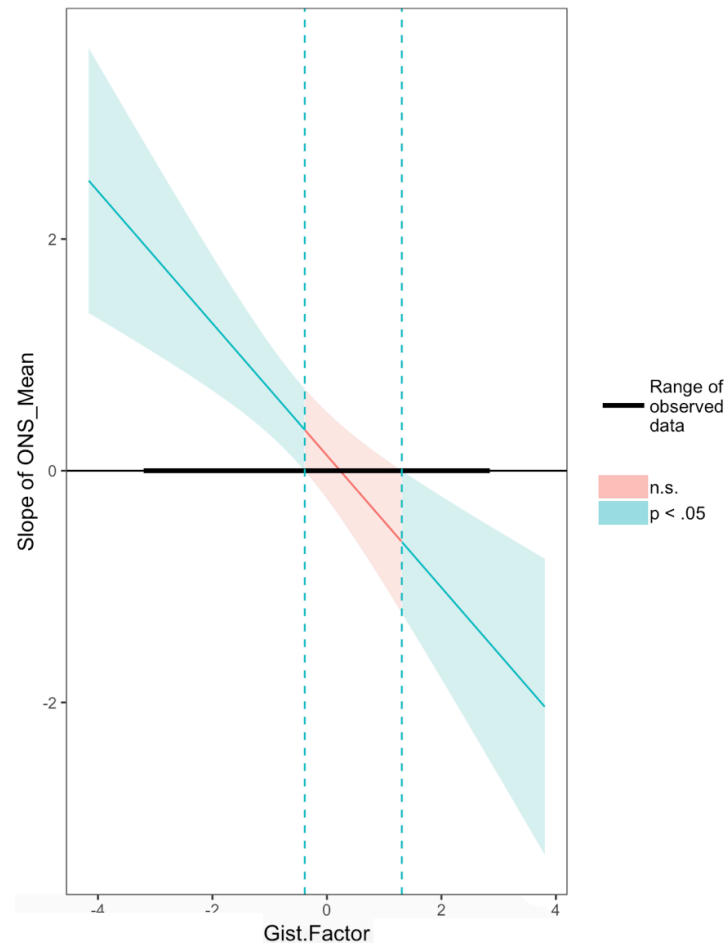


Figure 4. Johnson–Neyman regions of significance for the conditional effect of ONS on concussion reporting intentions. When the mean-centered Gist factor is outside the interval $[-0.39, 1.31]$, the slope of mean-centered ONS is significant at $p < .05$. Interval is calculated using false discovery rate adjusted $t = 2.10$. The range of observed values of the mean-centered Gist factor is $[-3.16, 2.80]$.

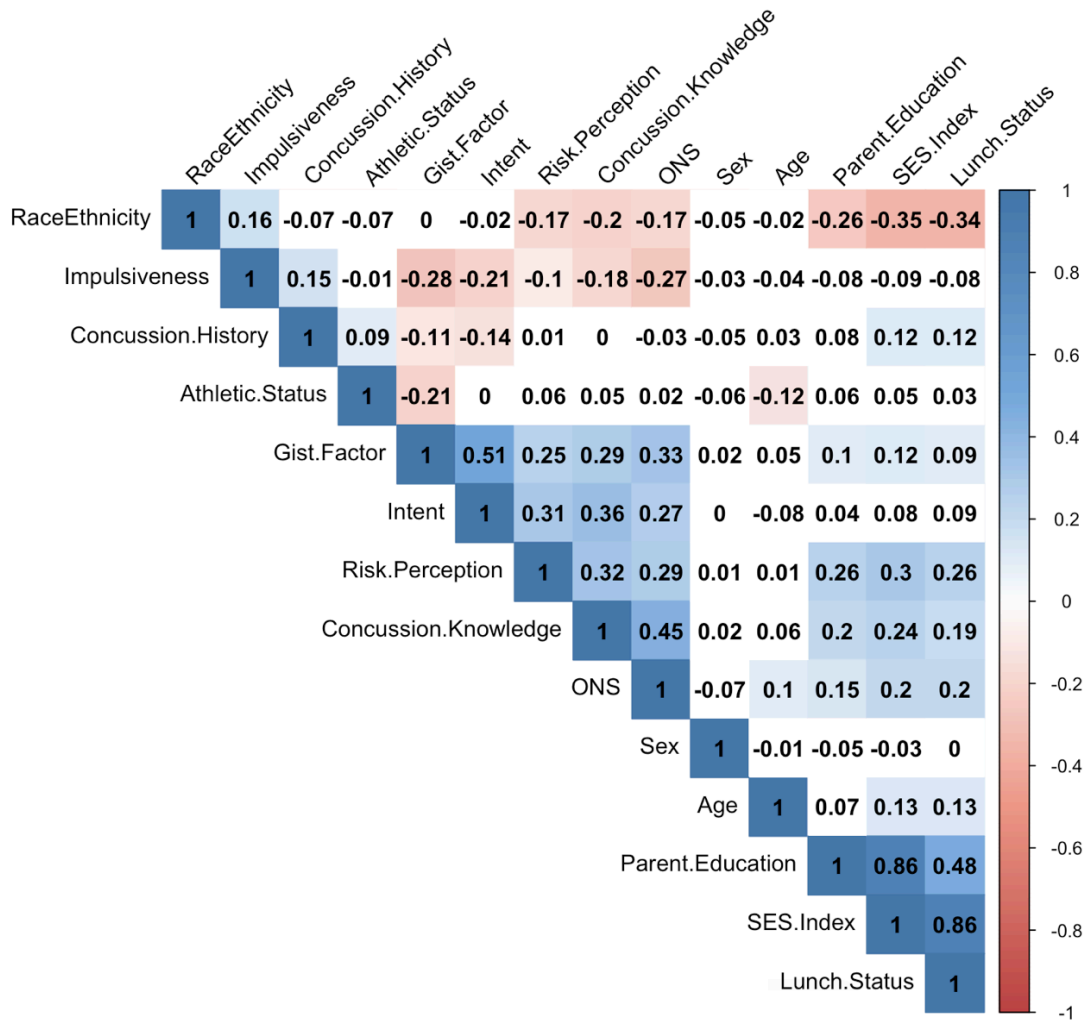


Figure 5. Correlogram of all measures used in Study 2. Pearson's Bivariate Correlation Coefficients significant at the 0.05 alpha level are denoted by color. Hierarchical clustering was used to identify hidden structure and pattern in the matrix. Race/ethnicity was coded as 0 for Non-Hispanic White and 1 for Hispanic and/or non-White. Athletic status was coded as 0 for nonathlete and 1 for athlete. Sex was coded as 0 for male and 1 for female. Age was in years. Parental education ranged from 1 (less than high school) to 4 (4-year degree or more). Lunch status was coded as 0 for yes and 1 for no. SES Index is a combined measure based on the mean of parental education and free lunch status (with both variables z-scored; higher scores indicate higher levels of SES).

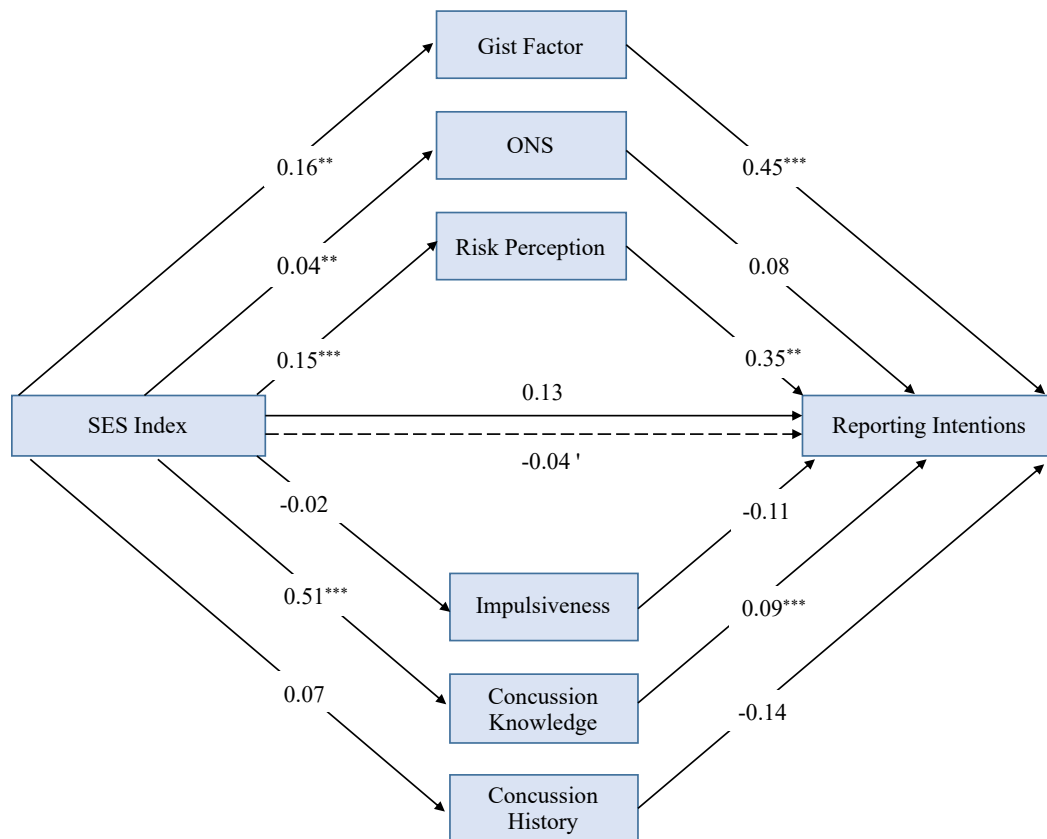


Figure 6. Values shown are unstandardized regression coefficients. The Gist factor, risk perception, and concussions knowledge significantly mediated the association between the SES Index and reporting intentions ($n = 466$). The solid line between SES Index and reporting intentions represents the total association (c path). The dotted line represents the direct association (c' path). Covariates were age in years, sex, race/ethnicity, and athletic status.